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13. SUPPLEMENTARY NOTES					
14. ABSTRACT An acoustical assessment was performed on the Combat Arms Firing Range at Grand Forks AFB in August 2014. It was determined that the noise in the firing range did not meet the definition of impulse noise for the M870 and M9 in accordance with Air Force Occupational Safety and Health (AFOSH) Standard 48-20 due to acoustical reflections. Conversely, the noise in the firing range met the definition of impulse noise for the M4 in accordance with AFOSH Standard 48-20. Due to the fact that training for all three weapons occurs in this facility, it was recommended that acoustical absorption be added to the walls to reduce the reverberant field.					
15. SUBJECT TERMS Impulse noise, impact noise, continuous noise, decay time, Combat Arms, CATM, firing range, hearing, acoustics, noise, firearms, weapon type, L_{eq}					
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DEPARTMENT OF THE AIR FORCE
USAF SCHOOL OF AEROSPACE MEDICINE (AFMC)
WRIGHT-PATTERSON AFB OH

23 January 2015

MEMORANDUM FOR 319 MDOS/SGOJ

ATTN: CAPT ADAM COOMBER
1599 J STREET
GRAND FORKS AFB, ND 58204

FROM: USAFSAM/OEC

2510 Fifth Street
Wright-Patterson AFB OH 45433

SUBJECT: Consultative Letter, AFRL-SA-WP-CL-2015-0002, Acoustical Evaluation of
Combat Arms Firing Range, Grand Forks AFB, North Dakota

1. INTRODUCTION:

a. *Purpose:* From 18-20 August 2014, the United States Air Force School of Aerospace Medicine, Consultative Services Division (USAFSAM/OEC), at the request of AMC/SGPB and 319 MDOS/SGOJ, conducted an acoustical evaluation of the Combat Arms firing range at Grand Forks AFB, North Dakota. The purpose of this assessment was to classify the measured noise exposure as continuous or impulse, explain the classification as it pertains to Air Force Occupational Safety and Health (AFOSH) Standard 48-20, *Occupational Noise and Hearing Conservation Program*, and provide recommendations for mitigating exposure. The process of assessing impulse noise at a firing range is a very complex task requiring specialized equipment. USAFSAM/OEC is the only AF Bioenvironmental Engineering resource with both the skilled personnel and equipment to accomplish these risk management/mitigation surveys.

b. *Survey Personnel:* Two Bioenvironmental Engineering Technicians, Consultative Services Division, USAFSAM/OEC.

c. *Personnel Contacted:*

- (1) Bioenvironmental Engineer, 319 MDOS/SGOJ
- (2) Bioenvironmental Engineering Technician, 319 MDOS/SGOJ
- (3) NCOIC, Combat Arms, 319 SFS/S4C
- (4) Combat Arms Instructor, 319 SFS/S4C

d. *Equipment:*

- (1) B&K PULSE Analyzer, Type 3052-A-030, SN: 3052-105153
- (2) B&K Microphone, Type 4128C 2530, SN: 2856097, 2856098
- (3) B&K Head and Torso Simulator (HATS), Model 4128C, S/N: 2425802
- (4) Quest Calibrator, Model # QC-20, SN QF8050050

2. BACKGROUND:

a. The Grand Forks AFB Combat Arms firing range is partially enclosed, with 28 total firing positions. The 319th Security Force Squadron uses this firing range to train and qualify base personnel on M9 pistol, M4 rifle, and M870 shotgun weapons. Each firing position has a two-part metal door that is opened when that specific point is used for live-fire training. The walls and ceiling inside the building are covered with a hard building material (wood paneling), the floor is a smooth-poured concrete, and there is also ventilation duct work inside the building, shown in Figure 1. Steel safety baffles covered with plywood hang from the ceiling, down range of the firing line. These baffles are designed to deflect and prevent bullets from leaving the range. The floor down range of the firing line is loose gravel, shown in Figure 2.



Figure 1. Grand Forks AFB Combat Arms Firing Range Lanes

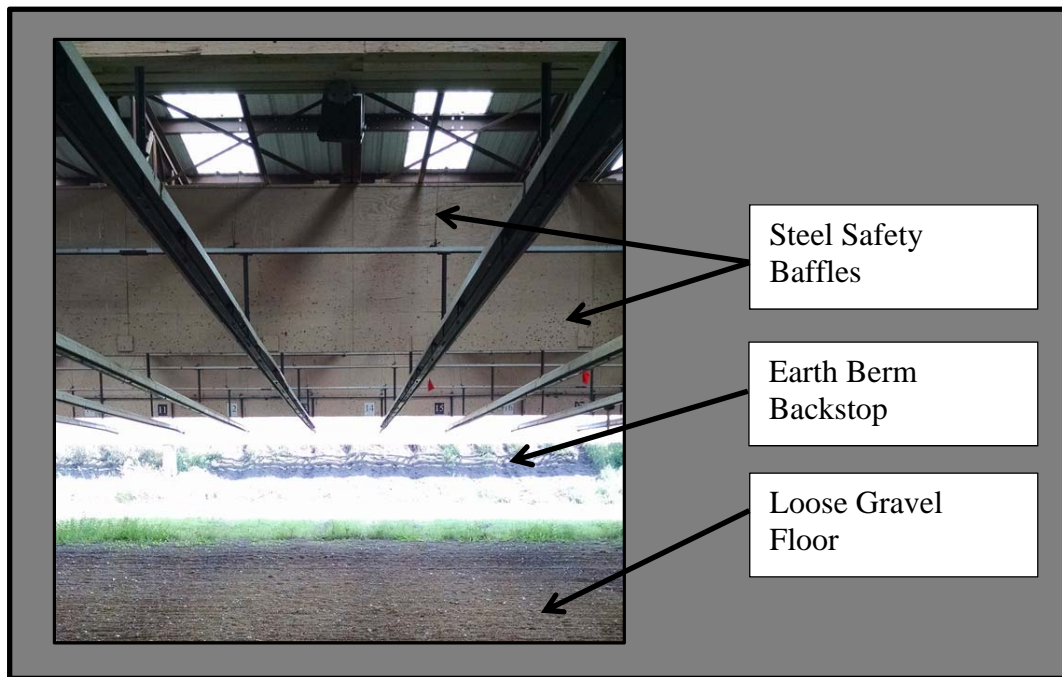


Figure 2. Grand Forks AFB Combat Arms Firing Range Down Range Area

b. The firing range has two distinct painted floor lines for students to reference. The first point of reference is the yellow safety line. Students must stand behind this line while not actively firing a weapon. The second point of reference is the red firing line, which is 8 feet forward (down range) of the yellow safety line. The red line is where each student actively fires a weapon at a down range target. During live-fire weapons training classes, instructors are positioned along the yellow line to ensure the range is safe and to provide assistance to students. During this assessment, USAFSAM/OEC observed Combat Arms instructors wearing dual hearing protection. Note: Moldex Camo ear plugs have a noise reduction rating of 33 decibels A-Weighted (dBA) and Peltor PowerComm headsets have a noise reduction rating of 24 dBA.

c. According to AFOSH Standard 48-20, “the maximum level of **continuous noise** that is allowed to reach the ear shall not exceed 115 dBA, and the maximum level of **impulse noise** that is allowed to reach the ear shall not exceed 140 dB peak sound pressure level (SPL).” AFOSH Standard 48-20 defines impulse noise as: “a short burst of acoustic energy consisting of either a single burst or a series of bursts. The pressure-time history of a single burst includes a rapid rise to a peak pressure followed by a somewhat lower decay of the pressure envelope to ambient pressure. A series of impulses may last longer than 1 second.”

d. A noise-reverberant field is created when the noise energy from a fired weapon is reflected off the ceiling, walls and floor surfaces, thereby increasing noise levels for a longer-than-1-second duration. The steel safety baffles, located down range of the firing line, are closely spaced and may reflect acoustical energy. As a result, these physical conditions may contribute to an increase in the duration of noise decay time.

3. METHODOLOGY:

a. *Sample Procedures:* USAFSAM/OEC collected three distinct sets of data simultaneously during each weapon type course of fire. USAFSAM/OEC used the first set of data, the SPL time-history, to calculate the average noise decay time for each of the weapon types. The second and third sets of data were the measured equivalent continuous noise level (L_{eq}) at-ear unprotected and at-ear protected L_{eq} noise levels, respectively. The unprotected at-ear L_{eq} data represent the average noise level instructors would be exposed to if they were not wearing hearing protection. The protected at-ear L_{eq} data are the noise levels the instructors would be exposed to when correctly wearing the ear plugs (Moldex Camo ear plugs) and communication headsets (Peltor PowerComm). Computer system performance limited the unprotected and protected L_{eq} data to 30-second increments during the course of live-fire. The data were averaged for each weapon type.

(1) USAFSAM/OEC measured the SPL time-histories corresponding to individual M4, M9, and M870 weapon firings with two 1/8-inch microphones. We placed each microphone 5 feet above ground level along the yellow safety line. USAFSAM/OEC used the data from these microphones to calculate and report the average decay time, as well as the peak SPLs for each weapon system.

(2) USAFSAM/OEC used the same 1/8-inch microphones to collect the average unprotected noise level values.

(3) The survey team collected the protected L_{eq} data using a HATS. The HATS is a mannequin with a 1/2-inch microphone embedded behind the earpiece. During this assessment, USAFSAM/OEC fitted the HATS with the same hearing protection devices the Combat Arms instructors wear and placed it 5 feet above ground level along the yellow safety line to simulate an instructor positioned at the yellow safety line while students were actively firing the weapons.

b. *SPL Time-Histories:* Time-histories are SPLs measured over a duration of approximately 10 seconds. This duration provides sufficient time to characterize the decay of the acoustical energy from ammunition discharge to background levels. Survey personnel used the time-histories to compute acoustical decay characteristics. The linear SPL decay rate, in decibels per second, is computed by selecting the linear decay phase of each time-history and performing a sound level versus time analysis through it. Decay times are calculated from 150 dB down to 80 dB. The decay rate is the slope of the decay time curve.

c. *Data Collection:* The survey team collected SPL time-history and L_{eq} data sets from three different weapon types representing the spectrum of exposure scenarios typical at this firing range. Figure 3 shows the layout of the firing range as well as where the microphones were positioned for each phase of data collection.

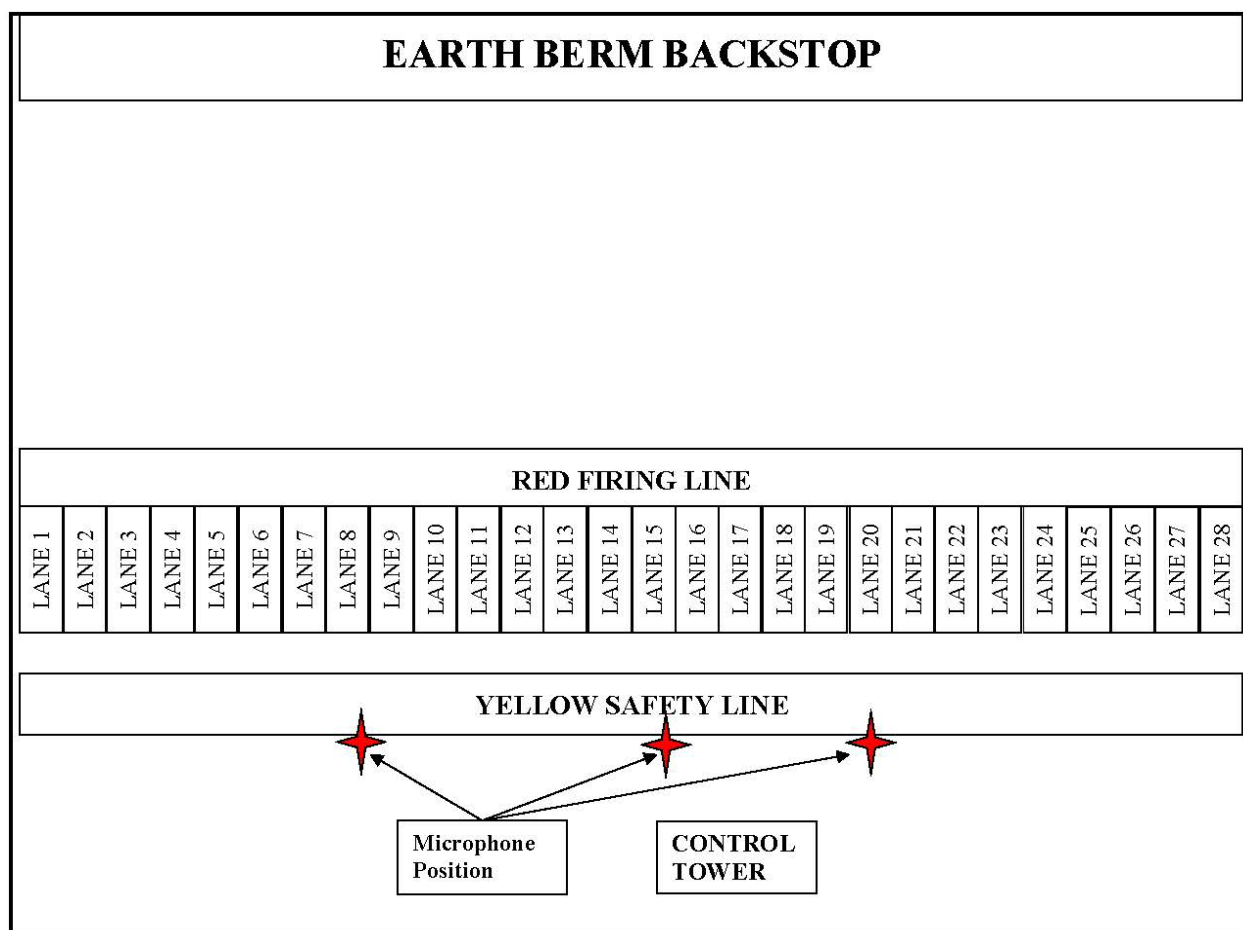


Figure 3. Grand Forks AFB Combat Arms Firing Range Layout and Microphone Positions

(1) For the first weapon type, 11 students each fired an M4 from firing lanes 5, 6, 7, 10, 12, 13, 14, 15, 18, 19, and 20. SPL time-histories and L_{eq} data were collected at each microphone position.

(2) For the second weapon type, seven students each fired an M9 from firing lanes 10, 11, 12, 13, 14, 15, and 18. SPL time-histories and L_{eq} data were collected at each microphone position.

(3) For the third weapon type, five students each fired an M870 from firing lanes 11, 12, 13, 14, and 15. SPL time-histories and L_{eq} data were collected at each microphone position.

4. RESULTS:

a. Under the conditions of this assessment, the M4 rifle noise meets the definition of impulse noise as shown in Table 1.

b. Under the conditions of the M9 pistol and M870 shotgun classes, the average noise decay times were both greater than 1 second, with peak SPLs greater than 115 dB; therefore, the noise is classified as continuous as shown in Table 1.

Table 1. Noise Characterization by Weapon Type

Weapon Type	Average Decay Time (s)	Noise Characterization	Measured Unprotected Peak Sound Pressure Level (dB)	Permissible Unprotected Continuous Noise Level (dB)	Exceeds Continuous Noise Std. (Yes/No)	Permissible Unprotected Impulse Noise Level (dB)	Exceeds Impulse Noise Std. (Yes/No)
M9	1.14	Continuous	150	115	Yes	N/A	N/A
M4	0.97	Impulse	154	N/A	N/A	140	Yes
M870	1.21	Continuous	140	115	Yes	N/A	N/A

c. Table 2 summarizes the average unprotected and protected L_{eq} for the Combat Arms instructors during the M9, M4, and M870 live-fire training courses.

Table 2. Unprotected and Protected Noise Level Averages and Allowable Exposure Times

Weapon Type	Measured Average Unprotected Noise Level, L_{eq} (dB)	Allowable Unprotected Exposure Time* (min)	Measured Average Protected Noise Level, L_{eq} (dB)	8-h Permissible Protected Exposure Level (dBA)	Allowable Protected Exposure Time* (min)
M9	107	3.0	62	85	No Limit
M4	112	0.9	68	85	No Limit
M870	109	1.9	65	85	No Limit

*Reference from AFOSH Standard 48-20, Table 3.

d. Table 3 summarizes the peak protected at-ear SPLs for the Combat Arms instructors during M9, M4, and M870 live-fire training.

Table 3. Peak Protected At-Ear SPLs

Weapon Type	Measured Peak SPL Protected (dB)	Permissible Noise Level (dB)	Exceeds Noise Std. (Yes/No)
M9	95	115	No
M4	102	140	No
M870	100	115	No

5. CONCLUSION:

a. The noise in the firing range is impulse noise during M4 classes because the average noise decay time, shown in Table 1, was less than 1 second. According to AFOSH Standard 48-20, there are no allowable unprotected exposures to peak SPLs greater 140 dB. The M4's SPL is 154 dB.

b. The noise in the firing range is continuous noise during M9 and M870 classes because the average noise decay time, shown in Table 1, for each of the weapon types was greater than 1 second. According to AFOSH Standard 48-20, there is no allowable unprotected exposure above 115 dBA. These weapons produce SPLs of 150 dB and 140 dB, respectively.

c. Combat Arms instructors should not conduct live-fire training courses unless wearing hearing protection (Table 2).

d. Combat Arms instructors are adequately protected from hazardous noise during M9, M4, and M870 classes while using Moldex Camo ear plugs and Peltor PowerComm headsets (Table 3).

6. RECOMMENDATIONS:

a. Install sound-absorbing material to reduce the reverberant field. Minimizing the reverberant field in the range should reduce the noise levels, further protecting instructors and students from hazardous noise exposure and improving verbal communication.

(1) The goal of the sound-absorbing material is to change the noise classification from continuous to impulse noise by reducing the noise decay time to less than 1 second and reduce peak SPLs below 140 dB in accordance with AFOSH Standard 48-20, para 2.11.3.1. Cover the first overhead baffle, the ceiling, and side walls from the red line back to the rear wall, and the rear wall, with acoustical absorption material. Quilted fiberglass, or other fiberglass panels wrapped in a manner allowing easy cleaning, is one option. There are also more fixed installation materials available, such as products offered by Pyrok or Troy Acoustics.

(2) Previous studies have shown that proper installation of sound-absorbing material(s) was successful in changing the noise characterization from continuous to impulse noise. Furthermore, the need for double hearing protection could be reduced or eliminated.

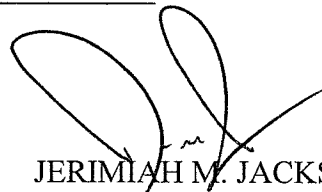
b. Combat Arms instructors should continue to wear dual hearing protection equivalent to at least the level of attenuation of those observed during this survey. Ear plugs need to have a noise reduction rating of at least 33 dBA and the ear muffs/communication headsets need to have a noise reduction rating of at least 24 dBA. We highly recommend students wear dual hearing protection, with the understanding that certain portions of the course require students to wear a helmet or other protective gear that will not accommodate the use of ear muffs.

c. Combat Arms instructors should be placed on the Hearing Conservation Program (HCP) and be considered for close scrutiny (frequent) audiograms as defined in AFOSH Standard 48-20. Frequent audiograms will allow the HCP Manager to identify any signs and symptoms of noise-induced hearing loss. The frequency of the audiograms will be determined locally by the Occupational and Environmental Health Working Group. Engineering controls must reduce noise decay time to less than 1 second to reduce the frequency or eliminate the need for close scrutiny audiograms.

d. Combat Arms instructors should provide just-in-time training to students on proper use of hearing protection devices as part of classroom instruction. There may be students who are required to qualify that are not enrolled in the HCP and do not receive this training. Additional information on proper insertion of foam ear plugs is available as a video for download from the National Institute for Occupational Safety and Health at <http://www.cdc.gov/niosh/mining/products/movies/rphhi.wmv>.

e. Request a USAFSAM follow-up noise assessment after acoustical treatment of the range.

7. If you have any further questions regarding this report, please contact TSgt Jerimiah Jackson at DSN 798-3312 or jerimiah.jackson@us.af.mil. Please direct any questions or comments regarding Industrial Hygiene Consultative support to Maj Marc Sylvander at DSN 798-3855 or marc.sylvander@us.af.mil. To improve our services, please complete the critique located at <https://www.surveymonkey.com/s/OECUSTOMERSURVEY>.



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